WESTERN PRAIRIE SOILS:

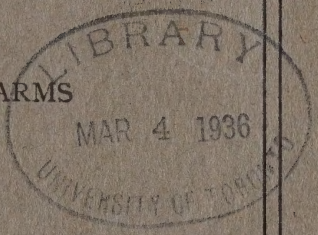
Their Nature and Composition

BY

FRANK T. SHUTT, M.A., D.Sc.

DOMINION CHEMIST

DIVISION OF CHEMISTRY
DOMINION EXPERIMENTAL FARMS



DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
BULLETIN No. 22—NEW SERIES

Reprint of Bulletin No. 6—Second Series

Published by direction of the Hon. W. R. Motherwell, Minister of Agriculture
Ottawa, 1923

DOMINION EXPERIMENTAL FARMS BRANCH

PERSONNEL

Director, E. S. Archibald, B.A., B.S.A.

Dominion Animal Husbandman.. .. .. G. B. Rothwell, B.S.A.
Dominion Field Husbandman.. .. .. E. S. Hopkins, B.S.A., M.S.
Dominion Horticulturist.. .. .. W. T. Macoun.
Dominion Cerealist.. .. .. L. H. Newman, B.S.A.
Dominion Agrostologist.. .. .. G. P. McRostie, B.S.A., Ph.D.
Dominion Chemist.. .. .. Frank T. Shutt, M.A., D.Sc.
Dominion Bacteriologist.. .. .. Grant Lochhead, Ph.D.
Dominion Botanist.. .. .. H. T. Gussow.
Dominion Poultry Husbandman.. .. .. F. C. Elford.
Dominion Tobacco Husbandman.. .. .. F. Charlan, B.Sc.
Dominion Apiarist.. .. .. C. B. Gooderham, B.S.A.
Chief Officer, Extension and Publicity.. .. .. F. C. Nunnick, B.S.A.
Chief Supervisor of Illustration Stations.. .. .. John Fixter.
Economic Fibre Specialist.. .. .. R. J. Hutchinson.

ALBERTA

Superintendent, Experimental Station, Lacombe, Alta., F. H. Reed, B.S.A.
Superintendent, Experimental Station, Lethbridge, Alta., W. H. Fairfield, M.Sc.
Superintendent, Experimental Sub-station, Beaverlodge, Alta., W. D. Albright.
Superintendent, Experimental Sub-station, Fort Vermilion, Alta., Robt. Jones.

BRITISH COLUMBIA

Superintendent, Experimental Farm, Agassiz, B.C., W. H. Hicks, B.S.A.
Superintendent, Experimental Station, Summerland, B.C., R. H. Helmer.
Superintendent, Experimental Station, Invermere, B.C., R. G. Newton, B.S.A.
Superintendent, Experimental Station, Sidney, B.C., E. M. Straight, B.S.A.

MANITOBA

Superintendent, Experimental Farm, Brandon, Man., W. C. McKillican, B.S.A.
Superintendent, Experimental Station, Morden, Man., W. R. Leslie, B.S.A.

SASKATCHEWAN

Superintendent, Experimental Farm, Indian Head, Sask., N. D. McKenzie, B.S.A.
Superintendent, Experimental Station, Rosthern, Sask., W. A. Munro, B.A., B.S.A.
Superintendent, Experimental Station, Scott, Sask., M. J. Tinline, B.S.A.
Superintendent, Experimental Station, Swift Current, Sask., J. G. Taggart, B.S.A.

NEW BRUNSWICK

Superintendent, Experimental Station, Fredericton, N.B., C. F. Bailey, B.S.A.

NOVA SCOTIA

Superintendent, Experimental Farm, Nappan, N.S., W. W. Baird, B.S.A.
Superintendent, Experimental Station, Kentville, N.S., W. S. Blair.

PRINCE EDWARD ISLAND

Superintendent, Experimental Station, Charlottetown, P.E.I., J. A. Clark, B.S.A.

ONTARIO

Central Experimental Farm, Ottawa, Ont.
Superintendent, Experimental Station, Kapuskasing, Ont., S. Ballantyne.
Superintendent, Tobacco Experimental Station, Harrow, Ont., D. D. Digges, B.S.A., M.S.A.

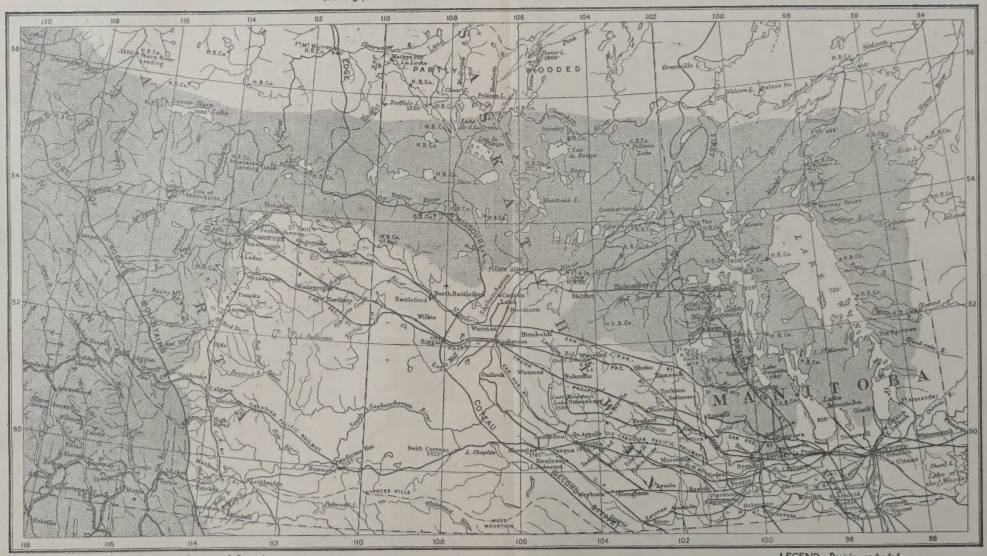
QUEBEC

Superintendent, Experimental Station, Cap Rouge, Que., G. A. Langelier, D.Sc.A.
Superintendent, Experimental Station, Lennoxville, Que., J. A. McClary.
Superintendent, Experimental Station, Ste. Anne de la Pocatière, Que., J. A. Ste. Marie, B.S.A.
Superintendent, Experimental Station, La Ferme, Que., P. Fortier, Agr.
Superintendent, Tobacco Experimental Station, Farnham, Que., J. E. Montreuil, B.S.A.

THE PROVINCES OF

MANITOBA, SASKATCHEWAN AND ALBERTA
CANADA

Showing prairie and wooded areas and the lines of the first and second steppes.



Sketch map prepared by Geological Survey of Canada.

LEGEND—Prairie, unshaded

Wooded, stippled

Area north of stippled, partly prairie and partly wooded.

To the Honourable
The Minister of Agriculture,
Ottawa.

SIR,—I have the honour to submit for your approval Bulletin No. 6, of the Second Series, entitled "Western Prairie Soils: Their Nature and Composition," prepared by Dr. Frank T. Shutt, Chemist to the Dominion Experimental Farms.

This bulletin contains the more important chemical results obtained on the soils of the great plains by the author during the last twenty years, together with conclusions drawn from this work. It outlines the nature and composition of the virgin prairie soils and the chief causes of their fertility, and further indicates methods of farming which, it is believed, will result in the maintenance of their productiveness.

In addition to the chemical work there will be found a report on the physical structure of these western prairie soils, kindly furnished by Dr. Edward J. Russell, Rothamsted Experiment Station, England, who is recognized as one of the leading soil chemists in Europe.

Useful information is also furnished respecting the physical geography of the prairies and the climatic conditions prevailing in northwestern Canada.

The bulletin is accompanied by a sketch map of the Provinces of Manitoba, Saskatchewan and Alberta, specially prepared by the Geological Survey of Canada to show the prairie and wooded areas and the lines of the first and second steppes.

This bulletin contains much valuable material and will be read with interest by those seeking information regarding the soils, the general climatic conditions and the productive possibilities of the Canadian Northwest.

I have the honour to be,

Sir,

Your obedient servant,

WM. SAUNDERS,
Director, Dominion Experimental Farms,

OTTAWA, July 21, 1910.

56578—1

CONTENTS

WESTERN PRAIRIE SOILS

THEIR NATURE AND COMPOSITION

BY

FRANK T. SHUTT, M.A., D.Sc., F.I.C.
Chemist, Dominion Experimental Farms.

PHYSICAL GEOGRAPHY OF THE GREAT PLAINS REGION IN CANADA

It will be desirable, by way of preface, to say a word or two regarding the physical geography of the district, the soils of which form the subject of this bulletin.

The term prairies, as applied to the Canadian Northwest, is a comprehensive one, and is used to denote all that lower portion of the Great Plains Region north of the 49th parallel found within the confines of the three western provinces, Manitoba, Saskatchewan and Alberta. Commencing some fifty miles east of Winnipeg, at the western edge or rim of the Laurentian area, it extends westward to the foothills of the Rockies, though it must not be supposed that this immense stretch of country, some 800 miles if measured near the southern boundaries of these provinces, is one continuous, uninterrupted prairie or plain. It is rather, as we shall see, a series of three great plains, marked off by more or less distinct lines of escarpment which frequently take the form of ridges and wooded hills. Considering the plains as a whole, they are found to narrow as we proceed northward, contracting to about 400 miles at the 56th parallel, and to still less north of the 62nd parallel. They may be said to terminate about the 65th parallel or with the shores of the Great Bear Lake. So far as concerns Canada it may, therefore, be considered as, in general, a huge wedge-shaped area extending northward and with its base lying along the Canadian frontier.

Settlement began in the south of this prairie country, and by rapid strides is now yearly extending northward. Twelve years ago, the late Dr. Geo. M. Dawson, then Director of the Geological Survey of Canada, in describing this area, wrote as follows: " The southern part of this great plain is not only the most important from an economic point of view, but also that about which most is known. It includes the wide prairie country of the Canadian west, with a spread of about 193,000 square miles of open grass land, an area more than twice that of Great Britain. Beyond the North Saskatchewan River, the plain becomes essentially a region of forest, with only occasional prairie tracts such as those of the Peace River valley." Since the foregoing was written, thousands have taken up land in the Northwest, and every year has seen successful grain-growing pushed farther and farther to the north.

We have briefly referred to the three steppes which constitute this interior plain. The first and lowest of these prairie levels is that of the Red River valley with an elevation of about 800 feet above the sea. Its northern portion is occupied by the Winnipeg group of lakes, and to the south of Lake Winnipeg, in the language of Dr. Dawson "it comprises some 7,000 square miles of prairie land, which, to the eye, is absolutely flat, although rising uniformly to the east and west of the river. This is the former bed of the glacial " Lake Agassiz," the sediments of which constitute the richest wheat lands of Manitoba."*

*Handbook of Canada, 1897.

The second or middle prairie, with an average elevation of 1,600 feet, extends from the escarpment forming the western boundary of the first prairie to a second fairly well marked and nearly parallel rise known as the Missouri Coteau. The first escarpment referred to comprises the so called "Pembina Mountain" in the south, and continues in a northwesterly direction including the Riding, Duck, Porcupine and Pasquia hills. The approximate area of this plain is given as 105,000 square miles, more than half of which is stated to be open prairie. It is less regular in its surface than the Red River valley or lower prairie level, undulations, low hills and ridges being not uncommon. The soil is by no means as uniform in character and richness as that of the first prairie, though large areas are of exceedingly fine quality and extremely fertile.

The third steppe, with an average elevation of 3,000 feet, continues from the Missouri Coteau to the Rockies, and includes the western portion of Saskatchewan and Alberta, south of the North Saskatchewan River. Between the 49th and 54th parallels it has an area of about 134,000 square miles, open prairie land for the most part in its southern portion, but wooded towards its northern and northwestern confines. Its topography is still more diversified than that of the second plain, due, according to Dr. Dawson, to more energetic and longer action of the denuding forces of rain and rivers, both before and after the glacial period. The character of the soil is still more varied than that of the second steppe; while there is much that is fertile and good—indeed, excellent—areas of some magnitude exist which, without special methods to overcome the presence of alkali, insufficient precipitation or other unfavourable conditions, cannot be profitably farmed.

Climatic Conditions

As climatic conditions very largely determine agricultural possibilities, a few general considerations may be added to the foregoing outline on the temperature and rainfall of the Canadian Northwest. Considered broadly, the summers are characterized by high day temperatures and an abundance of sunshine, the winters by clear, very cold weather. Usually spring advances very rapidly, for, as pointed out by Mr. Stupart,* Director of the Canadian Meteorological Service though the mean temperature in Manitoba during April and May may be in the neighbourhood of 35°, the daily maximum would be at least 10° to 12° higher. The annual precipitation over the whole area is comparatively light, but is somewhat greater for the first than for the second and third prairie levels. In a general way, we might say that the rainfall becomes lighter as we proceed westward. The greater part of the rain over the district, however, falls during the growing season, and hence is particularly effective agriculturally. The distribution has been found one that, for the most part, is well adapted to the production of the finest quality of wheat. In considering the climate of the Canadian prairies, Mr. Stupart remarks that "the fact should not be lost sight of that, although the total annual precipitation only averages 13·35 inches for the territories (now the provinces of Saskatchewan and Alberta) and 17·34 inches for Manitoba, the amount falling between April 1 and October 1 is respectively 9·39 inches and 12·87 inches, or 70·3 and 74·2 per cent of the whole. The average, 12.87 inches, in Manitoba is not far short of the average for Ontario during the same six months.*

Area Suitable for Farming.

If there is any one fact more than another regarding Canada that has in recent years been heralded abroad, and that has served to attract attention to the Dominion, it is the almost limitless expanse and the immense fertility of her western prairies. It is not our intention to burden this bulletin with statistics,

*Handbook of Canada, 1897.

but it will be of interest here to make one or two statements respecting the extent of these western lands and the possibilities that exist for expansion in wheat production and general farming. It is estimated that there are in the three western provinces about 180,000,000 acres suitable for cultivation, the greater part of which is adapted to wheat growing. Of this area, probably not more than six per cent is at present under cultivation. A further territory to the north of Alberta and Saskatchewan, within the boundaries of Mackenzie, Keewatin, Ungava and Yukon, contains more than 900,000,000 acres, and it has already been shown that wheat can be successfully grown at several points within this immense area.

Western Agricultural Problems Demanding Soil Analysis

It is, perhaps, scarcely necessary to say that we have not made any systematic, comprehensive laboratory examination of the soils covering these immense tracts of land. Such a work would have been quite impossible, though the types of soils in the prairie region, as might be supposed, are not so numerous as in Eastern Canada or British Columbia. Further, the chemical work of the Experimental Farms has been directed more particularly towards the solution of those agricultural problems which demanded immediate attention in all parts of the Dominion; and the general and high fertility of these prairie soils has rendered unnecessary, for the most part, assistance from the chemist in their management. It has only been, therefore, in certain specific cases, quite limited in number, that we have made analyses of these soils, to ascertain whether a district were affected with alkali, to learn if the failure reported were due to an insufficient rainfall or to poverty of the soil, and occasionally to furnish information regarding the character of the soil in some new district about to be opened up for settlement. From the soils so examined, probably in the neighbourhood of 200 samples, I have for our present purpose selected only a few, but these have been chosen with great care, as representative of large, uniform areas of virgin, i.e., uncropped, unmanured land, together with one or two samples of cultivated soils, the examination of which was undertaken in connection with certain problems referred to in the following paragraph.

Supplementary to the analytical work done with the view of ascertaining the amounts of total and available plant food present, we have studied, to some extent, the following questions relating to northwestern agriculture: methods of culture as affecting conservation of soil moisture, nitrification and exhaustion of fertility through continuous grain growing, and the effect of irrigation on the plant food content of the soil. As these are all matters that serve to bring out the nature of soils, and, further, have yielded important results, looking to the future economic management of the land, we have thought it well to incorporate some account of these researches.

CHARACTERISTICS OF PRAIRIE SOILS

Humus and Nitrogen Content

If we were asked to state what, in our opinion, constitutes the essential or distinguishing characteristic of the western prairie soils, we should unhesitatingly answer that it is the large proportion of vegetable matter and its concomitant nitrogen they possess. It is to this fact, unquestionably, that they primarily owe their remarkable fertility and lasting quality. For the most part, they certainly contain abundant stores of the mineral elements of plant food, but in this respect they do not differ from many soils of less productiveness in other parts of the Dominion. It is the larger percentage of nitrogen-holding humus-forming material and its intimate corporation with the sand and clay that give to these soils their superiority, chemically, physically and biologically.

This conclusion regarding the relationship between the organic content and the crop-producing power of arable soils is the result of our work and observation in studying Canadian soils in general during the past twenty years. We have invariably found that the soils of great productiveness are characterized by large percentages of organic matter and nitrogen, and on the other hand that worn, or partially exhausted soils, resulting from continuous grain growing or other irrational treatment and soils from naturally poor areas, show meagre amounts of these constituents.

We have further noticed, as far as soils in humid and semi-humid districts are concerned, that there exists a relationship between the organic matter and the nitrogen—that methods of culture which increase the amount of the former raise the percentage of the latter, and on the other hand when the organic matter is destroyed, nitrogen is dissipated.

Functions of Humus.—But apart from the fact that in humus we find nature's storehouse for nitrogen—nitrogen that may be readily nitrified and made available for crop use, we must also recognize it as liberating, during its further decay, goodly proportions of potash, phosphoric acid and lime, so that, in all probability, a large part of the soil food supply of the growing crop is obtained from humus.

Equally important with the chemical value of humus is its influence on the physical condition of the soil. This is most markedly felt in increasing the capacity of the soil for holding moisture. Our investigations have shown that soils of the same type from adjoining areas, apparently under the same climatic conditions and with equal drainage, will retain moisture in proportion to their organic matter content. We have found that these prairie soils, during the growing season, may retain amounts of water far in excess of those present in soils less rich in organic matter though favoured with a heavier precipitation—as in Eastern Canada. Further, the high absorptive capacity of these soils under suitable cultural methods allows moisture to be held over from one season to another, and thus it is possible, in districts of scanty precipitation, by means of a fallow, to secure two good crops in three years, when only very meagre yields would be obtained if the land were seeded every year. The properties of humus as favourably modifying the tilth and temperature of both clays and sands are familiar to all and need not here be enlarged upon.

Biologically, we unfortunately have no data to offer respecting these prairie soils, except as to nitrification. That a distinct relationship exists between the organic matter content and the bacterial life of the soil, there can be but little doubt. We, nowadays, recognize that these micro-organisms are an important factor in the elaboration of assimilable plant food. The growth of crops depends largely upon the rate of nitrification during their vegetative period, and while temperature and moisture largely control this process, the amount of nitrates formed must be materially affected by the quantity of the food supply the micro-organisms find in the form of partially decomposed organic matter.

Nitrogen as an index of Fertility.—In speaking thus of humus-forming material and the various ways in which it may beneficially affect fertility, the prime importance of nitrogen, its chief constituent, must not be overlooked. Our experimental work with soils *in situ* has assured us that of all the elements of plant food, nitrogen is the most potent in its influence on crop production. It has already been stated that a high nitrogen content is, in soils of humid and semi-humid districts, invariably associated with a goodly proportion of humus-forming material, and it is difficult, therefore, at times to ascribe to each of these its own proper share in affecting the yield. At all events, as regards these

prairie soils, nitrogen may be regarded as the chief index of their fertility, the most reliable measure of their crop-producing power—and this is true for both clay and sandy loams. In this connection, it may be remarked that the extraordinary growth that characterizes vegetation on the prairie as soon as the season opens is unquestionably due, for the most part, to the fact that very rapid nitrification takes place in the spring and early summer months, consequent upon the large water content of the soil and the high temperatures which then prevail.

Causes of Fertility.—We may now inquire briefly as to the cause of the richness of these prairie soils. The answer is simple, and, I believe, satisfactory. It is due to the tremendous accumulation of nitrogenous organic matter with its associated mineral constituents—the remains of countless generations of plant life—for, since the glacial period practically, these prairies have been continuously clothed with grasses and leguminous herbage. In these soils we have a remarkable example of the now well-known fact that land in sod increases in its nitrogen content, and also, no doubt, in its store of available plant food generally. We are certainly justified in considering that the great depth and high fertility of the prairie soils come to us as an accumulated legacy—one undoubtedly of the most valuable character, and one which, looking to the future prosperity of the west, we shall do well to conserve by rational methods of farming.*

If we push the inquiry farther and ask if there are any special reasons why these soils are in this respect so much more fertile than, say, those of Eastern Canada, we find the answer in the peculiarly favourable climatic conditions that have existed and still exist in the northwestern provinces for soil enrichment. High diurnal temperatures, long days, and a sufficient rainfall during the growing season are conducive to a most luxuriant growth. Rapid nitrification and conversion of inert mineral matter into available plant food take place practically throughout the summer, and withal there is no excess of rain to leach out and carry off the soluble constituents.† These conditions, further, tend to the production of more or less soluble mineral matter, alkaline in character, largely carbonate of lime, which renders the soil favourable for bacterial activity and vegetable life in general, and probably is of assistance in the formation of humus.** And lastly, we have the winter season with its intense cold practically locking up the stores of plant food from the autumn until the season again opens. Waste from leaching, such as occurs in countries in which the winter is mild and open, is thus prevented. In passing, it may be mentioned that this important fact has been, for the most part, overlooked by those who have written upon the various problems of western agriculture.

MANITOBAN SOILS

As illustrative of the soils of the first steppe—the prairie of the Red River valley—we have tabulated the results from a few typical examples, restricting the data to the more important constituents. As already stated, the plateau south of the Winnipeg group of lakes is of remarkable uniformity, and the data of Soil No. 1 are representative of a very large area of the immediate valley of

* The generally level character of the region also has precluded those losses of soil by erosion which naturally occur in more or less mountainous districts.

† And here perhaps the opportunity best presents itself to say a word in reply to the question frequently asked as to the probable necessity of using superphosphate or other mineral fertilizers in the Northwest. At present, at all events, there is no such necessity; over the larger portion of the prairie country, seasonal conditions undoubtedly to-day control the yields. As for the future, our work and observations lead us to believe that, if the humus content of the soil is well maintained, the day is far distant when there will be any need of phosphatic and potassic fertilizers.

** In speaking of the invariably alkaline reaction of prairie soils, it may be remarked that their black colour—which undoubtedly is an important factor in their absorption of heat as soon as the season opens—results, in all probability, from the action of the alkaline compounds referred to on the organic matter, and is not due to the presence of finely divided carbon from prairie fires, as advanced by the late Dr. Geo. M. Dawson.

the Red River, though perhaps not typical in all details of the whole plateau. It is a deep, black clay loam, of a fine and peculiarly characteristic granular order. In the air-dried condition, it reduces easily to a greyish-brown or greyish-black powder. Though there is present a considerable amount of undecomposed root fibre, the soil proper presents a remarkable homogeneity in appearance, indicating a process of physical refining in its formation and a uniformity in chemical composition. The very large amount of organic matter present is undoubtedly intimately incorporated with the clay and sand which consitute the basis of the soil.

Though containing a large amount of clay, laboratory experiments show that this soil does not readily "puddle" on moistening, nor on subsequent drying does it form into a hard mass, but granulates on moderate pressure. The large amount of organic matter present has already been remarked; it exceeds 25 per cent of the water-free soil. The nitrogen, calculated on the same basis, is found to be practically one per cent, from which it may be estimated that there is contained in an acre of soil to the depth of one foot from 20,000 to 25,000 pounds at least of this element. Since ordinary fertile soils to a like depth contain from 3,500 to 10,000 pounds, the vast reserve of this valuable constituent in this prairie soil is apparent.

The soil is also very rich in potash, containing an amount (1·033 per cent) far in excess of that ordinarily met with in the fertile soils of Eastern Canada. Our data have indicated that good agricultural soils possess usually between 0·25 and 0·5 per cent of potash.

Of phosphoric acid, it contains 0·29 per cent. This is slightly above the average, most of our good soils showing between 0·15 and 0·25 per cent of this element.

The fairly large percentage of lime is worthy of note, since it indicates not only a fair supply for crop use but also a condition of the soil that should be particularly favourable to nitrification.

We may safely conclude that, in these data, there is ample proof of abundant stores of plant food, and that this prairie land, as regards the elements of fertility, ranks with the richest of known soils.

The late Dr. Geo. M. Dawson, the eminent geologist and Canadian explorer, whom we have already quoted, wrote some years ago as follows regarding the prairie soil of the Red River valley: "Of the alluvial prairie of the Red River much has already been said, and the uniform fertility of its soil cannot be exaggerated. The surface, for a depth of two to four feet, is a dark mould, composed of the same material as the subsoil, but mingled with much vegetable matter. Its dark colour is no doubt due in part to the general accumulation of the charred grasses left by the prairie fires. The soil may be said to be ready for the plough, and, in turning the tough, thick prairie sod, the first year a crop of potatoes may be put in, though it is not sufficiently broken up till it has been subjected to a winter's frost. When the sod has rotted, the soil appears as a light, friable mould, easily worked and most favourable for agriculture. The marly alluvium underlying the vegetable mould would, in most countries, be considered a soil of the best quality, and the fertility of the ground may, therefore, be considered as practically inexhaustible."

"The area of this lowest prairie has been approximately stated as 6,900 square miles, but the whole is not at present suitable for agriculture. Small swamps are scattered pretty uniformly over its surface. The greater part of these swamps are, however, so situated as to be easily drained, either into the Red River or some of its tributaries, which are usually depressed 30 or 40 feet below the level of the surface."

Soils Nos. 2 and 3 are from Portage la Prairie, a district lying some 50 miles directly west of Winnipeg. It is one of the earliest settled localities in

the Northwest and has long enjoyed a reputation for producing wheat of the very highest quality. In No. 2 we have an example of the virgin prairie—uncropped and unmanured; in No. 3, the same soil after 25 years of cultivation, in which grain growing was interspersed with fallowing to clean the land. The virgin soil shows more root fibre than the cropped soil, and is somewhat darker in colour. Both might be described as black, friable loams, containing a considerable proportion of sand. The analytical data afford evidence of their richness in the elements of plant food, though they are not quite equal to the soil from the Red River valley either in "total" or "available" constituents.

A comparison may be made of Nos. 2 and 3, since it is of more than passing interest to learn what effect grain growing carried on for a number of years may have had on the composition of the soil. In the first place, it will be noticed, there has been a considerable reduction in the percentages of organic matter and nitrogen, consequent upon cultivation. This loss, as will be shown later when discussing certain Saskatchewan soils, has in a very large measure been due to fallowing—a system of immense value for the conservation of moisture and the freeing of the land from weeds, but one particularly wasteful as regards organic matter and nitrogen.

In the mineral constituents, no great differences are to be observed—the losses, so far as may be gauged by a chemical analysis, have not been at all excessive. This is not to be wondered at, as the wheat crop does not remove large amounts of plant food—it is not exhaustive according to the usual acceptation of the term—and in such a period as 25 years, representing, say, 16 crops, the effect upon the mineral stores of such rich soils would not be very noticeable.

Nos. 4 and 5 are composite samples from the Experimental Farm, Brandon, about 130 miles west of Winnipeg. They resulted from monthly collections (May to November) from plots under different cultural treatments in connection with moisture conservation experiments. In so far as physical character is concerned, these two samples are practically identical, the soil being a mellow, black loam of a somewhat sandy type.

The tabulated data bear out their similarity in composition, and we may undoubtedly regard them as typical and illustrative of the true prairie soil. We have only to remark the abundance of vegetable matter, the high nitrogen-content and the liberal supply of the mineral elements, and more particularly of potash and lime.

RESULTS CALCULATED TO WATER-FREE BASIS.

No.	Locality	Character of Soil	Organic and Volatile Matter (Loss on ignition)	Nitrogen	*Phosphoric Acid (P_2O_5)	*Potash (K_2O)	*Lime (CaO)	†Available Constituents		
								Phosphoric Acid (P_2O_5)	Potash (K_2O)	Lime (CaO)
			%	%	%	%	%	%	%	%
1	Red River valley, near Morris	Virgin prairie soil—black, heavy clay loam.	26·29	1·005	·288	1·033	1·89	·054	·076	·581
2	Portage la Prairie	Virgin prairie soil—black, sandy loam.	19·43	·651	·178	·658	1·05	·038	·056	·529
3	" "	Prairie soil, cropped for 25 years	14·79	·506	·170	·588	1·61	·033	·048	·776
4	Brandon	Prairie soil, black loam, rather sandy.	11·27	·346	·123	·819	1·14	·029	·057	·572
5	"	" " " "	12·05	·431	·136	·841	1·02	·027	·076	·462
6	Dauphin, Dauphin District	Black sandy loam	11·44	·363	·215	·687	1·89	·023	·018	1·121
7	Valley River, Dauphin District.	" "	21·54	·662	·155	·144	10·57	·007	·017	1·346
8	" " "	" "	13·11	·379	·133	·194	3·54	·007	·007	·949

*The solvent used in the determination of the "total" percentages of phosphoric-acid, potash and lime was hydrochloric acid sp. gr. 1·115, 10 grams of the air-dried soil being digested with 100 *c.c.* of the acid at the temperature of the water bath for 10 hours.

†In the estimation of the "available" constituents, 1 per cent citric acid solution was employed, digesting 100 grams of air-dried soil with 1,000 *c.c.* of the solvent for seven days at room temperatures.

No. 6 is a soil from the district immediately west of Lake Dauphin and northwest of Lake Manitoba. The area is one that, in parts, is covered with willow and other "scrub", necessitating clearance before cultivation. This soil is probably to be regarded as representative of those lands immediately surrounding the lakes, and subject to more or less flooding during the early part of the season, and for which drainage is, of course, necessary. It is a sandy loam, rich in organic matter, but with a sufficiency of clay to render it somewhat refractory on drying.

The data indicate it to be a soil of more than average fertility, and experience has borne out the conclusion drawn from the figures that it would, on drainage, prove suitable for wheat growing, excellent returns having been obtained in favourable seasons.

Nos. 7 and 8, the remaining two samples, are black, sandy loams from the Valley River, Dauphin district. They were collected in 1906 in an investigation to learn the influence of environment on the composition of wheat—a matter still under study in the Farm Laboratories. The significance of the soil data in the solution of the problem referred to need not now be discussed, but the richness of these loams in organic matter and their high nitrogen-content is worthy of remark.

In potash, they are decidedly poorer than the stronger or more clayey soils of the Northwest—indeed in this constituent they are somewhat below the average found for Canadian soils of medium fertility. The percentages of "available" potash are similarly low, though not reaching the limit set by Dyer as indicating the need of a potassic fertilizer.

With respect to phosphoric acid, we find considerably lower percentages than in the prairie soil of the Red River valley; the amounts, however, being about equal to those generally present in soils of average fertility. The large proportion of lime in these soils would undoubtedly favour rapid nitrification, and also serve to render effective the somewhat sparse supply of phosphoric acid.

In the samples discussed, two distinct types of Manitoban soils are represented, the heavy clay loam covering the true prairie region in the southern part of the province, and undoubtedly one of the finest wheat soils in the world, and the other representative of the sandy loams of the northwestern and more humid area, more or less covered with small trees and shrubs, a district regarding which we know less as to suitability for wheat growing, but, nevertheless, one which has produced profitable crops. Considered as a whole, the quality of the wheat of the northwestern section has not been equal to that of the southern and more distinctly prairie portion of the province, but there is evidence to support the view that the grain will improve in character with drainage and further cultivation of the soil.

SASKATCHEWAN SOILS

In reviewing, for the purposes of this bulletin, the soils of Saskatchewan examined by us during the past twenty years, a difficulty has been encountered in selecting only those which were truly representative of fairly large areas, for, as will be remembered, the second prairie steppe, comprising the larger part of this province, is not characterized by the uniformity noticed in the Red River valley. This fact precludes the possibility of presenting here examples of all types to be found, but it is worthy of remark that the larger number of the soils examined, and more particularly those in the noted wheat growing districts, have been found to be abundantly supplied with humus-forming material and nitrogen.

No. 1. A rich, black loam from Moosomin, a point on the main line of the C.P.R., 220 miles west of Winnipeg. The elevation of this locality is in the neighbourhood of 1,800 feet, and this soil may be regarded as fairly representative of the southeastern part of the second prairie level. As in the types we have considered from the first steppe, this true prairie soil possess abundant stores of plant food, and is, judged by accepted standards, one of high fertility. It has not, however, looked at simply from the chemical point of view, a rank equal to that from the valley of the Red River.

No. 2. From the district of Tisdale, on the Canadian Northern railway, about 160 miles due north of Indian Head. The district is one that in a large measure is comparable to the Dauphin country already described, being partly wooded with scrub, poplar, etc., and, therefore, unlike the true prairie, requiring clearance. It is a grayish-black loam of a decidedly clayey nature. The nitrogen, on the water-free soil, is almost half of one per cent, with notable amounts of potash and lime, and an average phosphoric acid content.

Nos. 3 and 4 are from Saltcoats and Yorkton, points on the northwestern branch of the C. P. R., 250 and 270 miles, respectively, west of Winnipeg, and approximately 75 miles northeast of Indian Head. Their similarity and comparative contiguity render unnecessary the separate consideration of these two soils. They are black, sandy loams of the true prairie type, rich in vegetable matter and nitrogen, with excellent percentages of phosphoric acid and potash.

Nos. 5 and 6 are black loams of a markedly sandy character, taken from areas that had been under grain (without manure) for a period of about fifteen years. Wolseley, the place of the collection, is about 20 miles east of Indian Head on the C. P. railway, a district which has produced large crops of very fine wheat. The data are of some interest since these soils have borne probably ten crops of grain, with a bare fallow every third summer. The evidence is that these soils are still of an exceedingly rich character, plentifully supplied with semi-decomposed vegetable matter and high in nitrogen; indeed, as regards these constituents, the data are not such as would differentiate them from virgin prairie soils. In "total" phosphoric acid they are decidedly above the average, but the amounts of this constituent immediately available are very small. This may be due to the taking up of the available phosphoric acid by the grain crop being more rapid than the conversion of the insoluble soil phosphates into assimilable forms.

Nos. 7 to 10 inclusive are from the Dominion Experimental Farm, Indian Head, and constitute a very instructive series, since they allow a comparison between the virgin prairie with the same soil after 22 years of cultivation without manure. The soil would be designated a heavy clay loam. A complete record of the cropping and fallowing since the prairie was broken in 1882, shows that the "cultivated" soil had borne six crops of wheat, four of barley and three of oats, with a fallow between each crop since 1887, nine fallows in all. The virgin soil was taken from an adjacent area, the point of collection being about 150 feet distant from where the cultivated soil had been taken. The samples were of a composite character, and every precaution was taken to have them thoroughly representative. There is every reason to suppose that the soil, over the whole area examined, was originally of an extremely uniform nature; in other words that, at the outset, the nitrogen-content was practically the same for the soils now designated as virgin and cultivated, respectively. The tabulated data show the percentages of organic matter and plant food in the first four and first eight inches of these soils, and make very clear that enormous losses of organic matter and nitrogen have followed upon the present method of continuously cropping with grain. The particulars respecting the nitrogen are given in the following arrangement, which allows a ready comparison of the two soils in this important matter.

DEPLETION OF THE NITROGEN.

NITROGEN-CONTENT OF VIRGIN AND CULTIVATED SOILS, INDIAN HEAD, SASK.

	To a Depth of 4 inches		To a Depth of 8 inches	
	Per cent	Lbs. per acre	Per cent	Lbs. per acre
Virgin soil	·409	3,824	·371	6,936
Cultivated soil	·259	2,421	·254	4,750
Difference or loss due to removal in crops and to cultural methods	·150	1,403	·117	2,186

Though the cultivated soil to-day, after nearly a quarter of a century's working, is still very rich, and possibly might yield as fine a crop as it did at the outset, yet, compared with the untouched prairie, it is seen to have lost practically one-third of its nitrogen.

An inquiry as to what proportion of this loss is due to removal by crops and what to cultural operations shows that the nitrogen contained in the various grain crops grown in the twenty-two years amounted to approximately 700 lbs. per acre. If we subtract this amount from the total loss, calculated to a depth of eight inches of soil, we shall see that more than twice as much nitrogen has been dissipated by methods of cultivation as has been removed in the crops. The loss ordinarily in the grain growing districts of the Northwest would not, in all probability, be as great as that here recorded, because, as a rule, the land is fallowed every third year only. Nevertheless, the deterioration must be marked, and, unless checked by the adoption of a system of rotation involving the formation of a sod and by the keeping of stock, will inevitably lead to that low degree of productiveness which now characterizes large areas in eastern North America. A study of these partially exhausted areas both in Canada and in the Northeastern States makes it clear that the deterioration has been, in a very large measure, due to the loss of humus and the dissipation of nitrogen consequent upon grain and potato growing, without any due return of organic matter.

A quite marked falling off in phosphoric acid is also to be noted, though what is perhaps of more significance is the reduction in the proportion of this element in the available condition. Since loss of phosphoric acid cannot be accounted for save in removal by crops, it would seem that in continuous grain growing the rate of abstraction exceeds that of conversion, a probability to which we have already referred.

In the "total" potash, the differences throughout the series are not large, but, as in the case of phosphoric acid, we find that the percentage of "available" in the cultivated soil is considerably less than in that of the prairie.*

No. 11 from the prairie in the neighbourhood of Vermilion Hills 130 miles west of Indian Head and some 20 miles north of Lake Chaplin. It is a dark-brown, sandy loam. In organic matter and nitrogen it is fully the equal of the heavier (clay) loams of the prairie, but as regards phosphoric acid, potash and lime it is, as might be expected, somewhat inferior. Although the "total" stores of this mineral plant food may not be very large, it is significant that the "assimilable" proportions are not less than in those heavier loams which are considered wheat soils *par excellence*.

*There is at times a certain loss of surface loam in the older cultivated areas by drifting and this in some cases would affect the phosphoric and potash content, and more especially that portion which is available.

SASKATCHEWAN SOILS.

Results calculated to water-free basis.

No.	Locality	Character of Soil	Organic and Volatile Matter (Loss on ignition)	Nitrogen	Phosphoric Acid (P_2O_5)	Potash (K_2O)	Lime (CaO)	Available Constituents		
								Phosphoric Acid (P_2O_5)	Potash (K_2O)	Lime (CaO)
			%	%	%	%	%	%	%	%
1	Moosomin	Black loam	11·79	·479	·116	·306	·95	.....	.....	.....
2	Tisdale	Grayish-black loam	14·23	·480	·202	·622	1·11	·024	·041	·568
3	Saltcoats	Black, sandy loam	13·54	·572	·213	·340	2·89	·018	·033	1·110
4	Yorkton	" "	14·01	·504	·211	·486	1·17	·025	·048	·531
5	Wolseley, N.E. ¼, sec. 27	Black loam (cultivated)	13·93	·514	·391	·555	·87	·005	·011	·306
6	" S.W. ¼, sec. 27	" "	10·98	·389	·369	·512	·76	·005	·018	·264
7	Indian Head	Black clay loam. Taken to a depth of 4 inches.	13·31	·409	·212	·863	1·26	·036	·070	1·187
8	"	Black clay loam. Taken to a depth of 8 inches.	12·83	·371	·234	·868	1·41	·032	·059	1·261
9	"	Black clay loam. Taken to a depth of 4 inches (cultivated).	10·20	·259	·159	·839	3·44	·016	·039	1·384
10	"	Black clay loam. Taken to a depth of 8 inces (cultivated).	10·70	·254	·163	·898	3·51	·013	·038	1·336
11	Vermilion Hills, Tp. 21, R. 5, W. 3rd.	Dark brown sandy loam	10·43	·354	·164	·164	·50	·044	·050	·383
12	Maple Creek, sec. 16, Tn. 11, R. 26, W. 3rd.	Heavy clay loam	5·54	·134	·064	·300	1·06	.....	.....	.....

No. 12 is from an area in the eastern part of the third steppe, 281 miles west of Indian Head along the main line of the C.P.R., and not far from the boundary between Saskatchewan and Alberta.

The district from which this soil was taken enjoys, as a rule, but a very limited rainfall, and, previous to the adoption of special methods for the conservation of moisture, gave but scanty yields. It was thought by some that the poor crops were due to a deficiency in some important fertilizing constituent, or to the presence of "alkali" or other matter deleterious to plant growth. From this analysis it will be seen that there is no lack of plant food, though the percentages of organic matter and nitrogen are only about one-half of those found in the richer prairie soils. Absence of "alkali" was established and the conclusion reached that the meagre yields were due to insufficient moisture rather than to any inherent fault in the soils.

ALBERTAN SOILS

No. 1. This soil, a black, sandy loam, was collected in the neighborhood of Tilley, a point on the main line of the C.P.R. about 50 miles west of Medicine Hat, and a district that, owing to sparse rainfall, has hitherto been considered better adapted to ranching than to grain growing. As in the case of the two immediately preceding examples, this soil was supposed to be deficient in some particular, or to contain alkali. The data, however, show that there is an abundance of plant food present and an entire absence of alkali. It has been demonstrated in recent years in this and similar districts, through improved methods of culture (resulting in the better conservation of soil-moisture) that the poor yields were not due to the poverty of the soil, but rather to insufficient water supply for the needs of the crop.

No. 2, from the Dominion Experimental Farm at Lethbridge, an important centre in southern Alberta, a true prairie region, and where, until recently, ranching has been the chief branch of agriculture followed. It is a district in which, speaking broadly, irrigation is desirable, if not indeed necessary; but in which, in many seasons, fairly good yields can be obtained by the adoption of proper cultural methods for the conservation of soil moisture. The soil appears to be extremely uniform in character and very productive, provided there is a sufficiency of moisture.

The sample, which in this case was taken to a depth of 12 inches, is a dark gray, inclining to black, sandy loam, light and friable, free from stones and containing an abundance of root fibres. Though not as rich in organic matter and nitrogen as the majority of the prairie soils hitherto considered, the results are quite satisfactory, especially when the greater depth to which this sample was taken is considered.* In mineral contituents it seems to be fairly well supplied, the amounts being such as are possessed by many soils of high productiveness.

No. 3 was collected from an uncultivated area on a bench in the valley of the Elbow River, some few miles from Calgary. The soil of the district is stated to be one "well fitted for either cultivation or grazing." It might be classed as a light to medium, black, prairie loam, especially rich in organic matter. It is practically neutral, and examination of the analytical data gives evidence that it is well supplied with all the essentials of plant growth, a very fair proportion of which appears to be in a condition immediately available.

Soils 4 and 5 were taken at no very great distance from the location of No. 3, and are in appearance very similar to it. They were examined to learn what effect irrigation might have on the stores of fertility. No. 4 is from a non-irrigated area, while No. 5 is from irrigated land, collected 50 feet from the lower side of an irrigation ditch, and 100 feet from No. 4.

* In all instances, unless otherwise specified the soil collections were made to a depth of 9 inches.

ALBERTAN SOILS.

RESULTS CALCULATED TO WATER-FREE BASIS.

No.	Locality	Character of Soil	Organic and Volatile Matter (Loss on ignition)	Nitrogen	*Phosphoric Acid (P_2O_5)	*Potash (K_2O)	*Lime (CaO)	†Available Constituents		
								Phosphoric Acid (P_2O_5)	Potash (K_2O)	Lime (CaO)
			%	%	%	%	%	%	%	%
1	Tilly, Tp. 16, R. 13, W. 4th	Sandy loam	11·12	·398	·174	·266	·37	.....	.....	.....
2	Lethbridge (1st foot)	Dark gray, or black sandy loam	5·89	·215	·123	·462	1·04	·008	·029	·959
3	Calgary, N.W. ¼, Sec. 21, Tp. 23, R. 1, W. 5th.	Black granular, sandy loam	13·69	·530	·210	·520	·71	·009	·035	·498
4	Calgary, S.W. ¼, Sec. 15, Tp. 23, R. 1, W. 5th.	Black granular, sandy loam, non-irrigated.	16·12	·549	·240	·380	·90	·004	·028	·440
5	Calgary, S.W. ¼, Sec. 15, Tp. 23, R. 1, W. 5th.	Black granular, sandy loam, irrigated	15·30	·574	·180	·380	1·28	·012	·035	·568
6	Innisfail, (1st foot)	Black, sandy loam	12·09	·403	·155	·384	·68	·016	·015	·392
7	Lacombe, (first 8 inches)	" "	8·78	·326	·136	·250	·63	·023	·024	·385
8	Lac la Nonne	" "	17·63	·673	·190	·611	1·00	·037	·022	·584
9	" "	" "	14·34	·514	·197	·673	1·24	·050	·035	·799

Undoubtedly the feature of greatest interest in the comparison of the data is the decidedly higher percentages of soluble (available) mineral constituents in the soil that had been irrigated, and it is important to note in considering this fact that, while the non-irrigated land is neutral, that of the irrigated area is slightly alkaline. These features are not uncommon to irrigated soils, and two possible causes therefor may be advanced. The first is the deposition of mineral salts from the irrigation water, and the second—probably the chief cause—is the bringing up of these compounds from the lower strata by increased capillarity induced by greater surface evaporation consequent upon irrigation.

It may be said that as southern Alberta is of the true prairie character, so northern Alberta is largely wooded, enjoying a more liberal rainfall and is naturally a country better adapted for mixed farming. The soils of northern Alberta are, for the most part, characterized by high percentages of organic matter and nitrogen, and in this respect are somewhat superior to those in the southern part of the province. We have in this a certain confirmation of the view that a relationship exists between rainfall and the organic content of the soil.

The samples so far considered from this province have been representative of areas in southern Alberta, the remaining examples are from points north of Calgary.

No. 6 is from Innisfail, an excellent district for dairying and mixed farming, some 80 miles north of Calgary on the Edmonton branch of the C. P. railway. This sample had been collected to a depth of 12 inches. As received, in the air-dried condition, it was a loose, friable, grayish-black, sandy loam, full of fibre and evidently rich in organic matter.

No. 7 is fairly representative of the soil on the recently acquired Dominion Experimental Farm at Lacombe, a point some 40 miles north of Innisfail. The country and soil in this neighbourhood are similar in character to those of the Innisfail district, just described, and indeed may be considered typical of a very large part of this northern portion of the province.

Nos. 8 and 9 are clay loams from Lac la Nonne, a district lying some 40 miles northwest of Edmonton. These loams are very similar, containing a large proportion of clay and well furnished with humus-forming material. They are of a grayish-black colour when air-dried. The chemical data well bear out the opinion formed from their inspection, and show that they are very rich in organic matter and nitrogen. The analysis also demonstrates that in potash and lime they are above the average and fairly well supplied in phosphoric acid. Under proper cultural operations and favourable climatic conditions, they should prove to be highly productive soils.

CONSERVATION OF SOIL MOISTURE

It will be evident from the facts here brought forward that, while it is advisable to adopt such a system of farming as will lead to the maintenance of fertility, the necessity of returning plant food in manures and fertilizers will not be generally felt for some time to come, so rich is the soil of the prairies over very large areas. But while, as yet, nitrogen (or any other element of fertility) cannot be regarded as the limiting factor, the amount of soil moisture available during the growing season does most markedly affect the yield. We consequently find that the important question of prairie farming, and more particularly in those districts of sparse rainfall, is the conservation of moisture for the crops' needs.

Fallowing is the general means adopted to this end. This comprises the preparation by deep ploughing of a reservoir, so to speak, for the storage of the rainfall in the soil, and the formation by frequent cultivation of a dry earth mulch to check evaporation. To ascertain the extent to which water

may be carried over by fallowing, from one season to another, a series of experiments was conducted some years ago on the Experimental Farms at Brandon and Indian Head, in which the amounts of moisture were determined to depths of 8 and 16 inches, respectively, on soils fallowed and cropped the previous season.* It was shown that at Brandon the soil which had been fallowed contained, during May, June and July—the months of growth—amounts of water varying from 330 to 65 tons, per acre, to a depth of 16 inches, over and above those in the soil that had borne a crop. Similarly, at Indian Head, the excess of moisture in the land that had been fallowed varied from 175 to 160 tons. While the amounts of moisture so conserved must depend upon the character of the season and the thoroughness with which the fallowing is carried out, the evidence furnished by this investigation is sufficient to show the great value of this practice as a means of storing up moisture for the crop of the succeeding year.*

MECHANICAL ANALYSES OF THE WESTERN PRAIRIE SOILS

For the following report on the mechanical conditions of these soils we are indebted to Dr. Edward J. Russell, Goldsmith Chemist, Rothamsted Experiment Station, Harpenden, England, who in addition to the work involved in making the mechanical analysis has very kindly written out in the appended notes his opinion—a very favourable one on the whole—of the structure of the soils as deduced from the physical data.

"*A. The Manitoban Soils.*—The Manitoba soils fall into three groups, Nos. 1 and 4—the Red River valley and Brandon soils being much the heaviest; Nos. 2 and 3 from Portage la Prairie are good loams; and Nos. 7 and 8, the Dauphin soils, are distinctly light and sandy."

"The Red River Valley and Brandon soils are characterized by the presence of rather large proportions of fine material, clay, fine silt and silt, and comparatively small proportions of coarser particles. They possess in a high degree all the properties associated with clay and silt; they are retentive of moisture and of plant food, and they are rich in potash. Such soils are very fertile wherever the air and moisture supply is satisfactory and the difficulty of getting a tilth not too great; the losses consequent on cultivation are reduced to a minimum and the plant is able to make the most of the food stuff present."

"The difficulties generally presented by this type of soil are that they tend to become very sticky and therefore expensive to cultivate, and they tend to become too compact for plant roots to get a proper air supply. In England similar soils have largely gone out of arable cultivation and are laid down to grass.† But there are two important features of the Manitoba soils that effectually prevent such stickiness and compactness; the presence of a large amount of organic matter, and the fact that they do not lie in a wet state throughout the winter. So long as these two features remain so long are the soils likely to continue fertile."

"The only one that is likely to change is the amount of organic matter. Continuous wheat cultivation necessarily results in the dissipation of organic

* The data of this investigation will be found in the report of the Chemist, Dominion Experimental Farms, 1900.

* Unfortunately, fallowing is not without its concomitant evils. We have already pointed out that dissipation of humus and nitrogen results from continuous grain growing, and that the greater part of this loss is more particularly consequent upon the stirring and opening up of the soil by repeated cultivation during the fallow season. It must now be stated that a further loss may result from fallowing; viz: the removal of more or less of the rich surface soil by erosion and drifting. The constant cultivation of the land breaks up the fibre—the binding element which gives the toughness to the prairie sod. As the fibre becomes shorter, the surface loam more readily dries and pulverizes; it is then easily carried away by the strong winds which prevail at certain seasons in prairie regions. Very serious losses have occurred from this cause in some of the older cultivated districts of the Northwest. The adoption of a cropping system in which the soil is occasionally put in sod suggests itself as the natural and best corrective.

† See footnote on page 24.

matter, and if it went on indefinitely it could not fail to bring the amount so low that undesirable features would present themselves just as they have done elsewhere. This, however, never need happen; as soon as the organic matter shows signs of falling too low it will only be necessary to grow green crops, preferably leguminous crops, periodically and to convert them into manure either by feeding on the land or by ploughing them in. At this stage lime and other mineral manures would probably be necessary. The data accumulating at the Experimental Station will enable the officers to give ample warning when the danger limit is being approached. There is no sign of it in the present sample."

"The Portage la Prairie soils are good loams closely resembling the famous brick earths of Kent and Sussex. As they possess less fine silt and clay than the Red River soils they are less dependent on their organic matter for the purposes of tilth; they would probably be easy to cultivate, however little there was. At the same time the organic matter is so great an advantage as a supply of nitrogenous plant food that it should not be allowed to fall too low."

"The Dauphin District soils are altogether different. They contain so little clay and fine silt that they derive but little retentive power from their mineral constituents. They are therefore, like the Red River valley soils, but to a very much greater extent, dependent for their value on their organic matter and their dryness during winter. If the organic matter fell too low the soils would cease to retain plant food and to resemble sandy loams; instead they would become like soils of similar mineral composition elsewhere, rather lean hungry sands, excellent for market garden purposes if highly manured, but not good farming soils. That the organic matter can fall, and fall quickly, is seen from the fact that No. 7, a freshly broken soil, contains 21·5 per cent, while No. 8, which has been in cultivation some time, contains only 13·1 per cent. But here again there is no reason why the danger limit should ever be reached; warning can be given by the Experiment Stations in ample time for the proper conservation measures to be taken."

MANITOBAN SOILS.

Locality	Red River Valley	Portage la Prairie	Portage la Prairie 25 years cropped	Brandon	Dauphin District	Dauphin District
No. of Sample	1	2	3	4	7	8
Soil						
Fine gravel* above 1 mm	.....	.....	.....	.....	.....	.....
Coarse sand 1 mm.—0·2 mm	1·64	4·32	11·38	2·53	21·13	19·55
Fine sand 0·2—0·04 mm	3·85	8·59	8·40	15·42	22·64	33·35
Silt 0·04—0·01 mm	17·13	29·98	29·65	17·74	10·67	11·00
Fine Silt 0·01—0·002 mm	28·20	15·61	14·56	16·10	6·43	6·16
Clay below 0·002 mm	23·27	16·53	14·17	29·21	3·36	4·11
Loss on ignition	26·29	19·43	14·79	11·25	21·54	13·11

*As the soil had already gone through a 1 mm. sieve the fine gravel could not be determined.

"*B. The Saskatchewan Soils.*—The Wolseley soil is remarkable for the uniform distribution of the various grades of particles. There is neither deficiency nor excess of anything; there is enough sand to make the soil work easily and to keep it open, but not too much; there is enough clay and silt to give

retentiveness and supply potash but not enough to make the soil difficult to work. It is not very different from the Portage la Prairie soil and the remarks made there apply here also. Even if the organic matter were much reduced the soil would probably be easily cultivated; at the same time it is so useful a source of plant food that it should not be allowed to fall too low."

"The Tisdale soil owes its clay-like nature partly to the absence of coarse sand and partly to the rather large quantity of clay present. It contains no mineral material capable of keeping it open and friable, but the abundance of organic matter present serves this purpose instead. The supply of organic matter must therefore be kept up."

"The Indian Head soils contain a large amount of clay, which, however, is tempered by the presence of 10 per cent of coarse sand. It would still be somewhat intractable were it not so well supplied with organic matter and lime, both of which must therefore be maintained at a sufficiently high level."

SASKATCHEWAN SOILS.

Locality	Tisdale	Wolseley	Indian Head	Indian Head
No. of Sample	2	5	8	A (2)
Soil				
Fine gravel (1) above 1 mm				
Coarse sand 1 mm.—0·2 mm	0·90	16·71	10·37	10·20
Fine sand 0·2—0·04 mm	24·15	14·85	13·68	9·95
Silt 0·04—0·01 mm	20·52	27·74	15·34	15·27
Fine Silt 0·01—0·002 mm	13·67	8·11	11·95	11·12
Clay below 0·002 mm	21·29	15·13	27·33	33·88
Loss on ignition	14·23	13·93	12·83	16·8

(1) As the soil had already gone through a 1 mm. sieve the fine gravel could not be determined.
(2) Not included in series chemically analysed.

"*C. The Albertan Soils.*—The Albertan soils all have one feature in common; they are well supplied with the finer particles that hold water near the surface for the crop. They are therefore admirably adapted to dry farming or irrigation; at the same time their physical structure is suited to most crops. The Lethbridge soil contains a larger proportion of coarse sand than the others and is therefore more likely to be easily worked; it does not, however, contain less clay and fine silt. The Lac la Nonne soil is much the heaviest, and its large proportion of clay is not counterbalanced by the presence of coarse sand; without the lime and organic matter present this soil would probably be difficult to cultivate."

ALBERTAN SOILS.

Locality	Leth-bridge (1st foot.)	Calgary	Innisfail	Lac la Nonne
No. of Sample	2	3	6	9
Soil				
Fine gravel* above 1 mm				
Coarse sand 1 mm.—0·2 mm	22·36	8·48	6·53	0·10
Fine sand 0·2—0·04 mm	25·05	26·66	16·36	10·57
Silt 0·04—0·01 mm	11·28	17·09	32·04	20·48
Fine Silt 0·01—0·002 mm	11·03	11·42	9·97	21·76
Clay below 0·002 mm	17·02	16·99	15·33	24·59
Loss on ignition	5·89	13·69	12·09	14·34

*As the soil had already gone through a 1 mm. sieve the fine gravel could not be determined.

"*Summary.*—Reviewing the whole of the analyses it will be seen that the majority of the soils are loams of very good type, which would still be good even if the organic matter were greatly reduced in amount although in that case they would require fertilizers. A large area of land represented by one or two of the samples—Red River valley, etc., is distinctly heavier and without its lime, its dryness in winter, and above all its organic matter would be difficult to work. If the depletion of organic matter is allowed to go too far these soils must suffer the fate that has befallen similar soils elsewhere—they will prove too difficult to cultivate and must go into pasture. *But only through long continued mismanagement would this result become possible. Lastly there are some soils of so light and sandy a nature that without their organic matter they would be too porous and lack retentiveness; for these also the conservation of the organic matter is highly important."

NOTES ON THE AGRICULTURE OF THE PRAIRIES

Manitoba.—Grain growing has been and will probably remain the most important feature in this province, and more especially in the Red River valley proper. However, recent years have witnessed a change. More and more stock is being kept and the tendency is, undoubtedly, largely towards smaller holdings and mixed, i. e., diversified farming. Dairying and the production of beef, mutton and pork are already extensively prosecuted with profit in many sections. Grass, roots and all classes of forage crops can be grown successfully. Of the cereals, wheat is the staple, but oats, barley and flax are also largely sown.

The soils, as we have seen, are varied in character, from heavy clays in the Red River valley to sandy loams in the northern parts, but all are richly endowed with vegetable matter and plant food, more particularly nitrogen. Many of these soils have now been cropped for 25 and 30 years, and, as yet, without any apparent falling off in productiveness. In this province the rainfall is usually sufficient for the needs of the crop, more particularly if special methods for its conservation are followed.

Saskatchewan.—Considering the province as a whole, the characterizing feature, as in Manitoba, is grain growing, chiefly wheat. There are, however,

* Though agreeing entirely with Dr. Russell in the necessity for maintaining the humus content of these soils, the writer is of the opinion that the unsatisfactory tilth there mentioned as arising in heavier soils in England from the depletion of humus, would not readily result in these prairie soils, owing to the drier summers and the colder winters (ensuring the steadily frozen condition of the soil from autumn till spring) which prevail in the Canadian North-west.

certain fairly well defined areas, each with its own more or less special adaptation to some particular branch of agriculture. Thus, for instance, in the western part cattle ranching on a large scale has for many years been the principal industry. A considerable proportion of the northern half of the province is as yet unsurveyed, but from such facts as have been gained, it will prove most suited to mixed farming.

As the province becomes more thickly settled, the one-crop system (grain and fallow) is giving place to more rational methods and diversified farming is becoming more and more popular.

Soils of several types are to be found, and wheat of excellent quality is apparently produced alike on clay and on sandy loams, provided climatic conditions are favourable.

It is as yet too early to notice any effect on the soils in the grain growing districts from the one-crop system, but as pointed out, there is a marked destruction of the organic matter and dissipation of the nitrogen where such a plan is followed, and this eventually will injuriously affect the soil both chemically and physically.

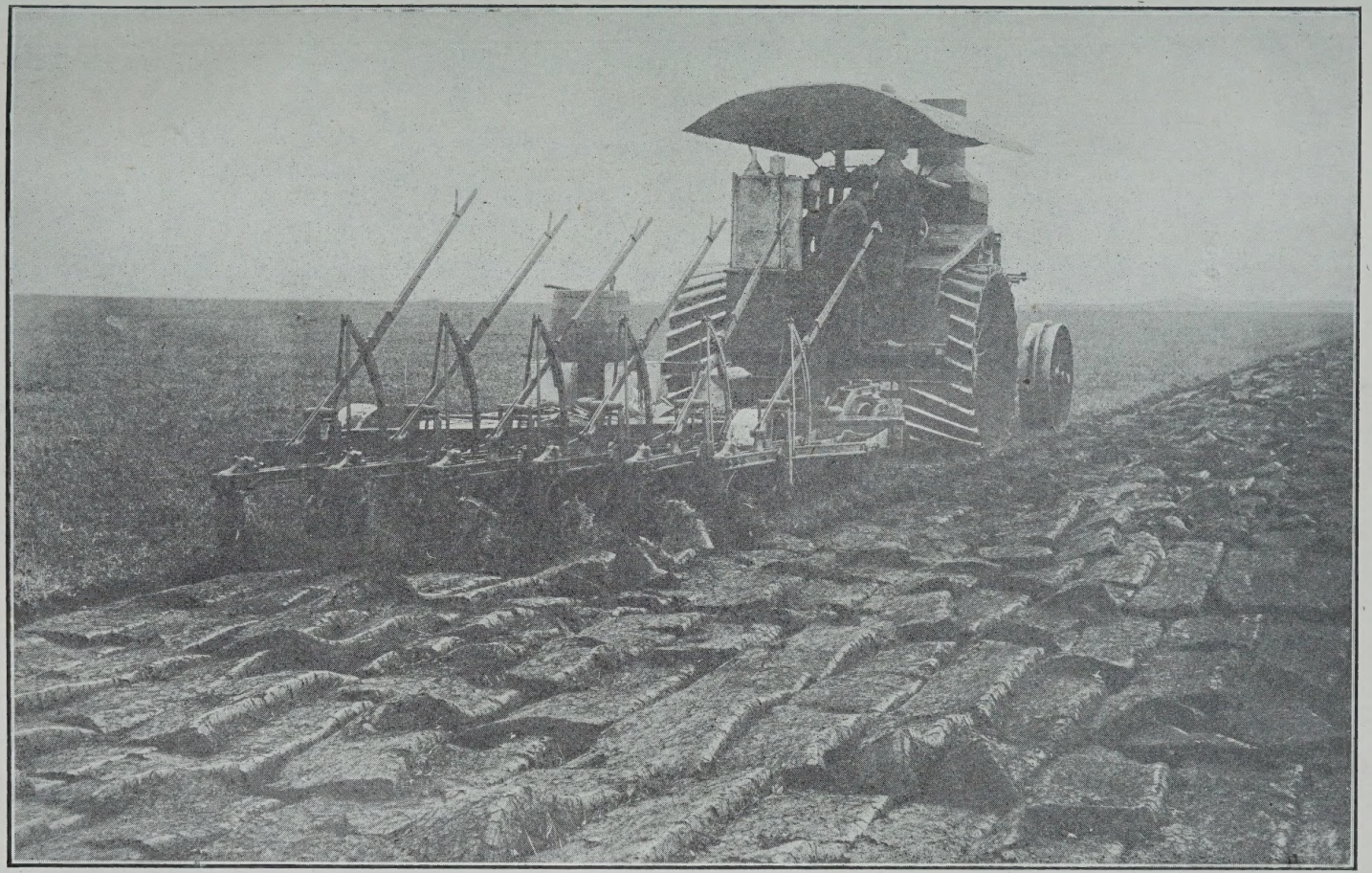
Alberta.—The world-wide reputation of Alberta as a typical ranching country has been well earned, though it is more particularly in the southern part of the province that this branch of agriculture has been followed. In more recent years, the growing of winter wheat has, in certain districts of the south, largely displaced the raising and grazing of stock.

Northern Alberta is more particularly adapted to mixed farming and for some years past, on the lines of railway, co-operative dairying has been profitably prosecuted.

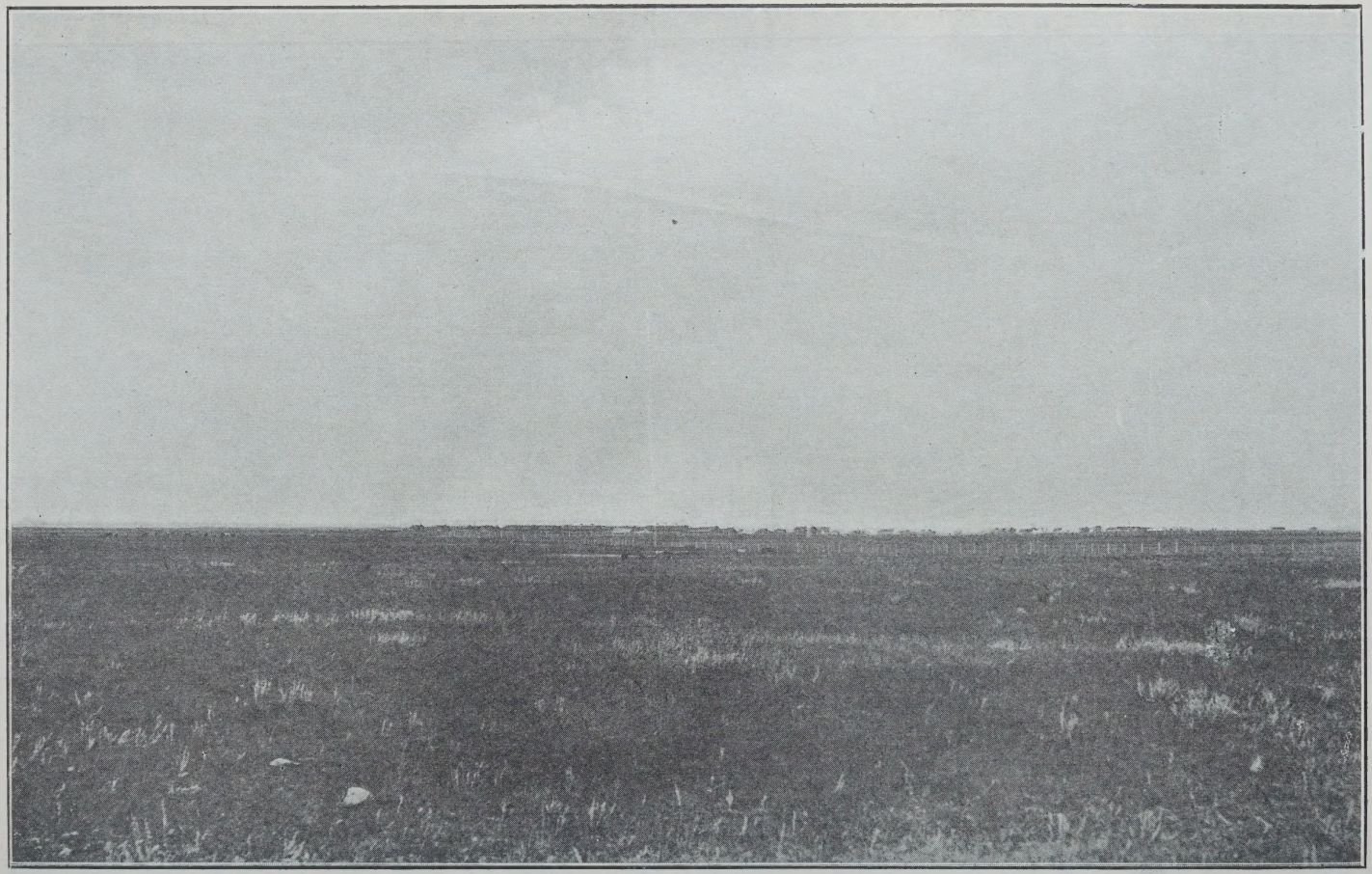
Southern Alberta may be considered a semi-arid country, and one, therefore, in which provision for irrigation is desirable. Mention may, therefore, be made of the extensive irrigation scheme of the Canadian Pacific Railway, by which about eleven hundred thousand acres immediately east of Calgary will eventually be watered. A survey of this territory by the writer in 1906 showed some variation in the character of its soils, though, like in all true prairie areas, uniformity was the prevailing feature, the characteristic soil being a moderately heavy black loam from 4 to 8 inches in depth, with a subsoil of chocolate-coloured clay. The whole area appears to be one well adapted to diversified farming.

In concluding this review, we may be allowed to again emphasize the general uniformity of the prairie soils, their richness in plant food, more especially in nitrogen, and their favourable physical conditions due, chiefly, to the large proportion of semi-decomposed vegetable matter they contain. Further, that, though the rainfall over a large portion of the prairies is not a generous one as judged by eastern standards, good yields may be obtained by fallowing, even in very dry districts. And lastly, that the climatic conditions usually prevailing in the prairie country are such as to bring about a rapid conversion of the stores of plant food into available forms without undue waste. They undoubtedly favour a luxuriant growth and early ripening of the crop.

While expressing this very favourable opinion of the Canadian Western Prairie soils it must, at the same time, be pointed out that exclusive grain growing and fallowing, now so common, must give place to more rational farming methods if the soil is to be maintained at its present high standard of productiveness. For the continued supply of available plant food, for the conservation of the necessary soil moisture and for the preservation of good tilth, the store of humus with its concomitant nitrogen must not be allowed to become depleted, and to this end the means are the adoption of a rotation, more particularly one containing a legume, and the keeping of live stock.



56578 Breaking with Gasoline Engine



56578 View of the Prairie near Macleod, Alta.

PUBLICATIONS ON WESTERN SOILS

The following publications of the Department of Agriculture relating to Western Soils are available on application to the Publications Branch, Department of Agriculture, Ottawa:—

Alkali Soils; Their Nature and Reclamation, Bulletin No. 4, second series.

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1923